"Characteristics of Electric Earth-current Disturbances, and their Origin." By J. E. TAYLOR. Communicated by Sir OLIVER LODGE, F.R.S. Received December 16, 1902,—Read January 22, 1903.

The following notes refer to effects which appear to have a distinct connection with the so-called "ionisation" of the upper regions of the atmosphere by radiations from the sun, and which have repeatedly attracted my attention during the course of recent experiments in wireless telegraphy for the British Postal Telegraphs.

In the electronic theory of the causes producing the aurora borealis, it is assumed that by the deflection of the course of the flying ions or electrons towards the poles, due to the earth's magnetic field, a concentration results in those neighbourhoods, giving rise to the phenomenon.

The effects classed by telegraph engineers as earth-currents have also, apparently, a direct connection with the ionisation of the atmosphere. As is well known, these are at times, particularly when auroral displays are in evidence, so strongly pronounced as to interfere more or less with ordinary telegraphic working on earthed circuits.

In special cases, where sensitive apparatus is used, they are, every day, sufficiently pronounced to cause disturbance, for some hours at least, even under normal conditions. They have been found to be particularly troublesome in the Post-office system of wireless telegraphy, in which a sensitive telephone receiver is connected in a low resistance circuit earthed in the sea at both ends.

To enumerate in a systematic manner the various investigations which have been made from time to time on the subject of earth-currents would involve a lengthy paper; but only the more prominent features which have forced themselves on my observation will here be briefly summarised.

The disturbances evidence themselves by producing various characteristic noises in the telephone receiver. They have not been confounded with ordinary telegraphic or other inductive disturbances, as they appear in circuits far removed from any such source of affection. In these latitudes they are always stronger and of more frequent occurrence in summer than in winter. They are daily in evidence for a few hours at or about the time of sunset, *i.e.*, whilst daylight is fading.

In general they do not evidence themselves to any great extent during broad daylight, but are readily precipitated by atmospheric electrical effects or any tendency to thunderstorms, and rarely, if ever, fail to herald the approach of a storm or gale.

The characteristic noises produced may be divided into five classes resembling—

(i) Uniform flowing or rushing of water: this is usually a daytime disturbance, and is occasionally of considerable vigour.

(ii) Intermittent crackling: an accompaniment of other disturbances.

(iii) Bubbling and boiling of water: the usual form of nightfall disturbance, but also frequently occurring in the daytime.

(iv) Rocket disturbances. These are peculiar and characteristic, having some resemblance to the sound produced by a rocket rising in the air. They commence with a shrill whistle and die away in a note of diminishing pitch. They vary in intensity, but always have a similar duration of from 2 to 4 seconds; are freely heard at night, and only occasionally during the day.

(v) Disturbances due to high frequency effects, inaudible on the telephone, but evidenced on the coherer, magnetic detector, or other form of Hertzian receiver.

These various disturbances were, for some time, very puzzling to me; but on perusing Professor J. J. Thomson's paper, read at the Royal Institution on 19th April, 1901, it speedily appeared highly probable that they were due to electrical effects produced in the atmosphere by the ionisation caused by solar radiations and the reaction on this ionisation by electric stresses in the atmosphere. The rocket disturbances, though they are probably not in themselves due solely to ionisation, furnished the first clue to this explanation. They are characteristic of an initial high velocity rapidly damped and ultimately dissipated. They have the same duration as is usually associated with the passage of a meteor across the heavens, and the assumption is that they are actually caused by the passage, in sufficient proximity, of meteoric bodies which set up electrical discharges in the upper rarefied atmosphere, these discharges inducing electric currents in the sea and collected therefrom by the circuit.

Assuming this explanation, it might reasonably be asked why such disturbances are not equally evident during the daytime as at night. The answer lies in the screening effect of the ionised (and therefore conducting) air during the daytime and the absence of such screening at night.

Professor J. J. Thomson has shown, in a modification of the well-known cloud experiment, how the ionisation of a gas may be cleared up or dissipated by an electric field. Doubtless the electric fields to which thunderstorms are due produce similar effects in the atmosphere on nature's gigantic scale. Hence we may expect, as is presumably the case, that the screening referred to above may sometimes be suspended for a time, even during broad daylight, and the rocket disturbances evidenced among others.

Now this assumption of a reaction between the electric stresses in

the atmosphere and the ionisation produced by the sun suggests the source of the other daytime disturbances referred to. It appears highly probable that they are the accompaniment of the clearing up process. Effects analogous to, if not actually, electric currents are doubtless produced in the atmosphere, which are induced in the sea and collected by the circuit. On the other hand, the nightfall disturbances are probably due to normal clearing up processes, revealed when the air becomes sufficiently non-conducting to act no longer as a screen. These suggestions, though by no means complete, are submitted for what they may be worth.

It is probable also that the diurnal variations of the earth's magnetic field are influenced by the same causes.

One more point. The periods of maximum disturbances, experienced on the earthed circuits referred to, appear to coincide with periods of maximum atmospheric disturbances on the newer Hertzian system of wireless telegraphy, and indicate the same source of trouble. Further, I would suggest that we have here a clue to the true explanation of the greater night-time efficiency in signalling observed by Mr. Marconi in recent experiments. With ionised air the electric waves will be partly broken up and absorbed, with consequent abstraction of energy from the transmission. At night, when the ionisation is cleared up, the strength of the radiated waves will be sustained.

Some interesting investigations by the aid of sounds produced, in a telephone, by the passage of electrical currents through rarified gases can no doubt be carried out. Professor Righi has already made some observations in this connection, but much more can yet be done.